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# Innovation Pushed Too Far Too Fast: The Destruction of the R101

Leadership ViTS  
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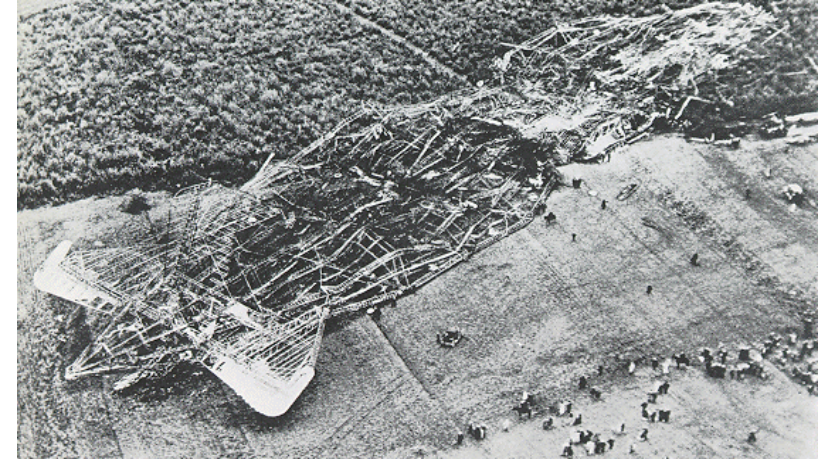
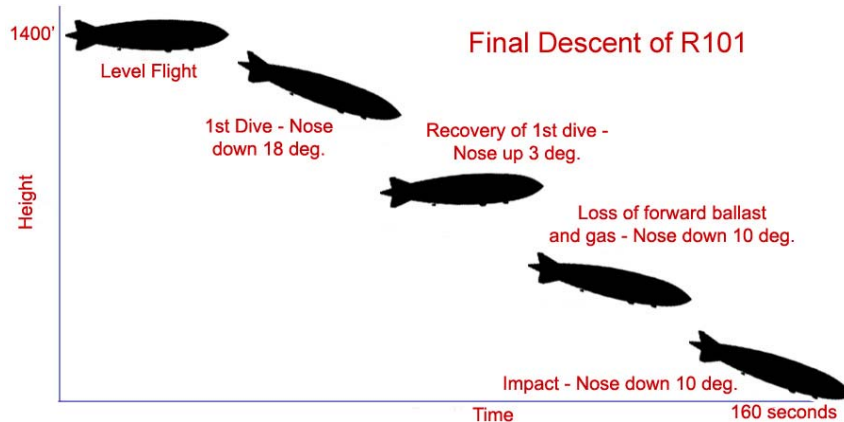
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<https://sma.nasa.gov/safety-messages>



# The Accident

- While en route from England to India on October 4, 1930, the R101 encountered severe weather over Beauvais, France.
- Gusting winds tore back the nose area's outer covering, exposing and rupturing the foremost gas bag which then began to accumulate rain water, reducing forward buoyancy and forcing the R101 into a steep dive.



- Despite efforts to level the ship, the R101 then went into a second dive and impacted the ground.
- The force of the impact twisted the starboard forward engine around on its struts, bringing it into contact with and igniting hydrogen from the ruptured forward envelope.
- Flames quickly engulfed the R101, killing 48 of the 54 passengers and crew aboard.



# Rushed Design and Testing

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- The R101 is a classic schedule-driven technology disaster
  - Political and press pressure, combined with the successful test flight three months earlier of a competing airship, resulted in an atmosphere where priority #1 was to fly the ship, with or without sufficient operational testing
- Several technology “innovations” were flawed
  - Using diesel engines, which ended up being underpowered (84% of spec), overweight (by 55%), and exhibited natural resonant vibration at idle and cruise that induced fuel leakage and caused structural damage
  - Using steel (instead of lighter aluminum) in airship rib structures, contributing to inadequate buoyancy margin
  - Employing newly-designed pressure valves on flotation bags. These valves turned out to be oversensitive to aircraft roll excursions, releasing gas when the airship needed it most.
  - A new method of manufacturing the outer skin that, in the end, resulted in brittle, crumbling material that may not have been completely replaced before flight
- Lack of proper design verification flight tests combined with the failure to couple design and flight test issues
  - “Heavy and sluggish” handling deficiencies were not corrected prior to first operational demonstration



## Proximate Causes in Event Chain

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- Loss of forward buoyancy due to weather-induced damage to the skin which caused the forward-most gas bag to rupture, deflate, and become saturated with rain water
- Hot engine contacting extremely combustible, leaking hydrogen gas during structural deformation at ground contact

## Causal Web – Underlying Issues

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- Time and development pressures
  - Political pressure, press criticisms, Government ministers' prestige, and competitive rivalry with another airship
- Off-nominal weather conditions
  - Though the acceptable operating conditions were unknown, R101 was launched into known poor operating conditions
- Ignored stand down call
  - The Air Ministry's airworthiness certification official's recommendation to revoke the R101's temporary "Permit to Fly" was discounted and ignored by middle managers
- Fundamental buoyancy and control issues
  - Overweight airship, leaking gas envelopes, oversensitive pressure valves, poor location of pressure equalization vents, brittle and crumbling outer skin, inadequate management of buoyancy margin, and inadequate response to flight testing deficiencies further compounded the situation



# NASA Applicability

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- Carefully evaluate technology readiness and ensure that sufficient testing is conducted before incorporating into a new design.
- Understand the integrated risk of introducing multiple innovations at the same time.
- Understand, evaluate, analyze, and act to correct off-nominal test or performance behavior within the system.
- Ensure that qualification testing/analysis reflects the full range of operating environments.
- Define specific meteorological operating constraints in the face of ever-present weather dangers.
- Perform proper systems engineering to continually couple/integrate design, test, and operational environments.
- Embrace the philosophy of incremental change in safety-critical systems.
- Use governance checks and balances to optimize risk management.